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Improvement of eating quality in rice

I. Variation in amylose content and gel consistency[1]

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Abstract : Amylose content and gel consistency are closely related with the eating quality of rice. The presecnt experiment was conducted to develop a quick and reliable method of defatting for analysis of amylose content, and also to look into intra-panicle and inter-panicle as well as inter-plant variabilities of gel consistency. The following results were obained.

1. Different values of amylose content between non-defatted and defatted seed material were observed. The defatting of brown rice powder was found to be necessary to avoid the disturbance of fat in the colorimetric reading during the course of amylose analysis. A simple and time saving method of defatting with the efficiency almost as good as the Soxhlet method was used in this study.

2. *Indica* type varieties were found to have a higher amylose content than *japonica* type varieties. In contrast to this, *indica* type varieties showed smaller value of gel consistency than *japonica* type varieties.

3. No difference in gel consistency between different panicles within a plant or different parts (lower, middle and upper) within a panicle was found. It is therefore considered that any part of a panicle or any panicle within a plant can be used as a representative sample for gel consistencn analysis.

4. Inter-plant difference in gel consistency within the same field was observed. Uniformity of soil and other environmental factors are essential to minimize this difference.

With the rapid economic growth in many Asian countries, both grain yield and eating quality are considered essential in rice breeding programs to meet the demands of people. Eating quality is generally determined by cohesiveness, tenderness and gloss of boiled rice grains [2,11,13] which are influenced mainly by amylose content [2,3,6,9,10,14]. The *japonica* rice is usually lower in amylose content and relatively sticky and glossy, while the *indica* rice is higher in amylose, and is dry, fluffy and harder in texture when cooked [5,8]. Amylose content of nonwaxy rice ranged from 7% to 34% and is generally classified into low (below 20%), medium (20-25%) and high (above 25 %) class-

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es.

Eating quality differs also from varieties with the same level of amylose content [1, 16,17]. This is due mainly to the difference in gel consistency [1,15,16,17]. The importance of gel consistency as the selection criterion for improving eating quality has been stressed by Perez [15]. A proper sampling technique as well as an accurate and speedy method for the analysis of amylose content and gel consistency are therefore impotrant in rice breeding programs.

The varietal variation in gel consistency has been studied by Cagamang *et al* [1]. However, no information is available on the intra-and inter-plant variation in amylose and gel consistency. The present study is thus conducted to look into the difference in gel consistency within and among field-grown rice plants in order to develop a proper sampling method. As seed fat is often a disturbing factor in amylose determination, variability due to defatting or non-defatting of rice samples is also investigated.

Materials and Methods

Analysis of amylose content

Two *japonica* rice varieties, Tainan 5 and Tainung 67, and two *indica* rice varieties, Taichung Native 1 and Chianung Sen 11, were grown in the experimental farm of Taiwan Agricultural Research Institute in the second crop season of 1978. Rice seeds harvested on a single plant basis were dehulled and ground into fine powders with an Udy's Cyclon grinder. The rice powders were then divided into 3 portions to study the effect of defatting on the analysis of amylose content.

One portion of the rice powder was defatted with petroleum ether by the Soxhlet method (D_S). Another was defatted by the conventional method (D_C) of the following procedures : 2 g of rice powder was mixed with 40ml of petroleum ether in a stoppered vial and placed in the laboratory at room temperature after vigorous shaking. The solution containing the extracted fat was discarded after 8 hrs of extraction. A second extraction of 10 hrs was made and the defatted powder was then dried in an over at 60°C. The third portion of rice powder was used as non-defatting control (D_O).

Amylose content was analyzed by the method of Juliano(1971) [4]. All chemical analysis was repeated four times. Statistical analysis by the split-plot technique was made using defatting method as the main plot and variety as the sub-plot.

Measurement of gel consistency

Japonica rice Taichung 65 and *indica* rice Chianung Sen 11, grown in the experimental field of Taiwan Agricultueal Research Institute in the second crop of 1978, were used as materials. Twenty plants of each variety were harvested for the study of inter-plant variability in gel consistency. Five best developed panicles within a plant were also taken to measure the intra-plant variability in gel consistency. The main panicle obtained from each plant was further divided into upper (including the uppermost 3 rachises), middle (middle 3 rachises) and lower (lower rachises) parts for th investigation of intra-panicle variation. Gel consistency was measured according to the method of Cagampang *et al.* [1]. Statistical analysis of data was made by using split-plot

design.

Results

1. Variation of amylose content due to different defatting methods

The amylose content of the tested rice varieties was given in Table 1. According to the data of D_S treatment(defatted by Soxhlet method), amylose contents of *japonica* rice varieties Tainung 67 and Tainan 5 were, respectively , 16.70% and 16.99%, which were much lower than those of the *indica* rices Taichung (N) 1 (27.17%) and Chianung Sen 11 (25.49%).

Table 1 also showed the effect of defatting method on the amylose content anlysis. Defatting caused significantly higher readings in amylose level than the non-defatting treatment for most varieties. For example, non-defatting (D_O) gave amylose contents of 14.58, 19.43 and 22.97%, respectively, for the rice varieties Tainung 67, Chianung Sen 11 and Taichung (N) 1. Corresponding values of the defftted samples (average of D_C and D_S) for the three varieties were 16.68, 27.01 and 25. 48%. However, on difference was observed in the *japonica* rice Tainan 5. Furthermore, it was noted in Table 1 that there was no significat difference in amylose values between the samples defatted by the conventional method (D_C) and by the Soxhlet methods (D_S).

Table. 1. Difference in mean amylose content in percent due to different defating methods[a]

Defatting method[b]	*Japonica* type.		*Indica* type	
	Taitung 67	Tainan 5	Chianung-Sen 11	Taichung Native 1
D_o	14.58 a	16.51 a	19.43 a	22.97 a
D_c	16.66 b	16.78 a	26.85 b	25.46 b
D_s	16.70 b	16.99 a	27.17 b	25.49 b

a. data are mean value (%) of 4 replication.

b. D_o : non-defatted material.

D_c : defatted by conventional method.

D_s : defatted by Soxhlet's method.

Analysis of variance for the effect of defatting showed an interaction between variety and treatment (Table-2) which was further analyzed and given in Table 3. As shown in Table 3, the influence of defatting on the determination of amylose content differed according to varieties. The most conspicuous interaction was observed in the non-defatted samples of Chianung Sen 11. The interaction between Tainan 5 and non-defatting showed a significant, positive value (1.838**) which was in accordance with the result shown in Table 1, i. e., no difference in amylose content between defatted and non-defatted samples.

Table. 2. Analysis of variance for effect of defating and non-defatting treatments on amylose content of rice

Source	df.	SS	MSE	F
replication	3	3.35	1.117	0.395
treatment (T)	2	105.94	52.970	18.737**
error (a)	6	10.52	1.753	—
variety (V)	3	809.17	269.723	95.400**
T X V	6	76.95	12.825	4.534*
error (b)	27	76.33	2.827	—
total	47	1,005.31	—	—

** significant at 1% level.

Table. 3. Interaction among defatting methods and amylose content in 4 varieties of rice

Variety	Defatting method[a]		
	D_o	D_c	D_s
Tainung 67	0.670	— 0.408	— 0.238
Tainan 5	1.838**	— 0.898	— 0.960
Chianung Sen 11	—2.965**	1.558*	1.393*
Taichung Native 1	0.415	— 0.278	— 0.165

a. D_o, D_c, D_s same as Table 2.

2. Intra-panilcle variation in gel consistency

Gel consistency measurement of the upper, middle and lower parts of single panicles is shown in Fig. 1 and Table 4. For the two varieties tested, average gel consistency of Taichung 65 (*japonica* type) was 48.4mm which was considerably greater than the 23.0 mm of *indica* rice Chianung Sen 11. It was also noticed that there ware no significant differences in gel consistency among different parts of a panicle (Tables 4 and 5). In other words, seeds from any part of the panicle could be used as a representative sample for the measurement of gel consistency.

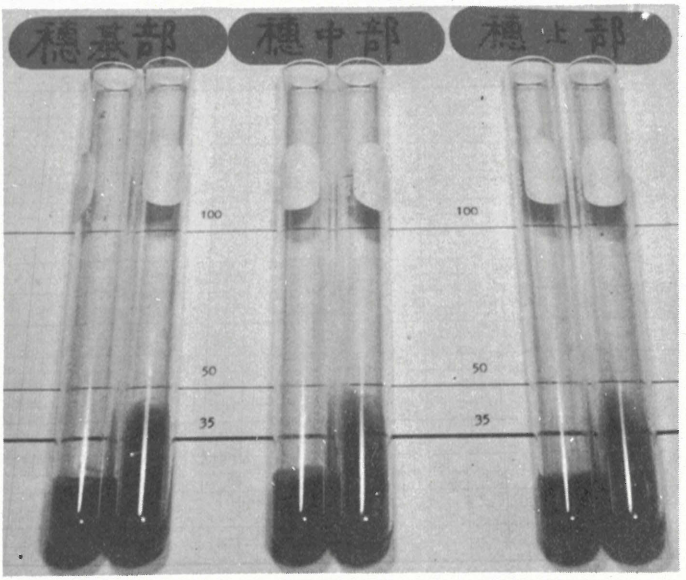

Fig. 1. Variation in gel consistency due to different varieties and different parts of a panicle. Left, middle and right sets are respectively lower, middle and upper parts of a panicle. Right and left tubes of each set are respectively Taichung 65 (*japonica type*) and Chianung Sen 11 (*indica* type).

Table. 4. Mean gel conssitency of different parts of a panicle in two varieties of rice[a]

Plant No.	Chianung Sen 11 (*indica* type)			Taichung 65 (*japonica* type)		
	lower	middle	upper	lower	mddle	upper
1	23.3	22.5	23.0	53.3	49.0	48.8
2	23.8	23.0	22.8	47.0	47.8	44.0
3	22.8	22.5	22.5	50.8	51.8	49.3
4	21.3	22.5	23.3	45.5	48.8	44.5
5	23.3	24.3	24.5	47.3	46.3	51.0
Mean	22.9 a	23.0 a	23.2 a	48.8 b	48.7 b	46.5 b

a. data are mean value (mm) of 4 replications.

b. means followed by the same letter are not significantly different at the 5% level.

Table. 5. Analysis of variance for gel consistency to determine intra-panicle variation in two rice varieties

Source[a]	df.	SS	MSE	F
panicle	4	28.58	7.145	2.546
variety (V)	1	4,808.26	4,808.260	1,713.560**
error (a)	4	30.38	7.595	—
panicle part (P)	2	1.50	0.750	0.267
V X P	2	3.92	1.960	0.699
error (b)	16	44.89	2.806	—
total	29	4,917.53	—	—

**, significant at 1% level.

3. Intra-and inter-plant variability in gel consistency

Five panicles from each of the twenty plants of Taichung 65 and Chianung Sen 11 were analyzed to study the inter-panicle and inter-plant variations in gel consistency. Based on the analysis of variance shown in Table 6, no significant differences were observed for mean gel consistency among different panicles within a plant. Furthermore, there was no interaction between panicle and variety. Therefore, it might be concluded that any best developed panicle in a plant can be a representative material for gel consistency analysis. However, a significant difference between plants was noticed (Table 6).

Table. 6. Analysis of variance for gel consistency to determine inter-panicle variation in two varieties of rice

Source	df.	SS	MSE	F
plant	19	2,169.455	137.866	8.854**
variety (V)	1	41,213.205	41,213.205	2,646.792**
error (a)	19	2,213.095	116.479	—
panicle (P)	4	14.480	3.620	0.233
V X P	4	33.520	8.380	0.538
error (b)	152	2,366.800	15.571	—
total	199	48,460.555	—	—

**, significant at 1% level.

Discussion

Eating quality of rice is generally controlled by amylose content, gel consistency, gelatinization temperature and protein content. Rice starch is composed of amylose and amylopectin. Their proportion in the grain influences greatly the cooking and eating qualities [7,17]. Cooked rice is more fluffy when amylose content is high, and is more sticky when amylose content is relatively low. In the present study, we found that *indica* type varieties contained more amylose on a percentage basis(25-27%) than *japonica* type varieties (16-17%) which is in close agreement with previous reports [5,8].

In breeding for proper amylose content, breeders are often confronted with the problem of how to make an efficient chemical analysis. Williams *et al.* [18] first developed a method of amylose analysis by removing seed fat with methanol. Juliano [4] simplified the procedure for the analysis of milled rice. However, the Soxhlet method of defatting with 95% alcohol is still necessary for brown rice. As the Soxhlet procedure requires special equipments and is low in efficiency, a more convenient method is desired for routine analysis. The results of this study indicated that amylose values of the samples defatted by the easy conventional method is almost identical with those defatted by the traditional Soxhlet method. In other words, extraction of fat with petroleum ether by incubation at room temperature is acceptable for precision and accuracy in amylose analysis.

Another quality character, gel consistency, can be used to measure the softnese of cooked rice. The gel formed by boiling starch (rice powder) in 0.2N potassium hydroxide can be classified into hard (25-35mm), medium (36-50mm) and soft (over 50mm) based on the length of cooled gel [1]. The gel consistency of saft and medium types is more desirable and hence should be selected from the breeding materials. General analysis of gol consistency has been made by Cagampang *et al* [1]. However, no information is available on the intra-panicle and intra-and inter-plant variations in gel consistency. Data in Table 6 showed that measurements of gel consistency were similar from samples obtained from different portions of a panicle or from different panicles of a plant. Therefore, the grains in any part of the panicle or any best developed panicle within a plant can be sampled for analysis of gel consistency. On the other hand, significant difference was found between plants (Table 6) which might be due to the influences of envirinmental factors. It is suggested that the samples for analysis should be taken from plants grown under a homogeneous condition to ensure uniform growth of plants. More studies along this line should be made in the future. Investigation on the genetic aspect of amylose content and gel consistency are now underway.

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Literatnre Cited

1. Cagampang, G. B., C. M. Perez and B. O . Juliano. 1973. A gel consistency for eating quality of rice. J. Sci. Fd. Agri. 24 : 1589-1594.

2. Juliano, B. O. 1967. Physiochemical studies of rice protein and starch Int. Rice Comm. Newsletter (Sp. issue) : 93-105.
3. Juliano, B. O. 1965. Relation of starch composition, protein content and gelatinization temperature to cooking and eating qualities of milled rice. Fd. Technol. 19 : 1006-1001.
4. Juliano, B. O. 1971. A simplified assay for milled rice amylose. Cereal Sci. Today 16 : 334-339.
5. Juliano, B. O. 1972. Physiochemical properties of starch and protein in relation to grain quality and nutritional value of rice. In Rice Breeding p389-405.
6. Juliano, B. O. 1975. The gel consistency and viscosity test as an index of eating quality of milled rice. IRRI. Jan. 18.
7. Juliano, B. O. 1979. Amylose analysis in rice-a review. In Proceeding of the workshop on chemical aspects of rice grain quality. IRRI. p251-260.
8. Juliano, B. O., G. M. Bautista, J. C. Lugay and A. C. Peyes. 1964a. Studies on the physiochemical properties of rice. J. Agri. Food chem. 12 : 131-130.
9. Juliano, B. O., G. B. Cagampang, L. J. Crus and R. G. Santiago. 1964b. Some physiochemical properties of rice in Southeast Asia. Cereal Chem 41 : 275-285.
10. Juliano, B. O., E. L. Albano and G. B. Cagampang. 1964c. Variability in protein content, amylose content and alkali digestibility of rice varieties in Asia. Philippine Agri. 48 : 238-241.
11. Juliano, B. O., L. U. Onate and A. M. del Mundo. 1972. Note : Amylose and protein contents of milled rice as eating quality factors. Philippine Agri. 56 : 44-47.
12. Juliano, B. O. and A. A. Perdon, 1975. Gel and molecular properties of nonwaxy rice. Die Starke. 27 : 115-120.
13. Onate, L. U. and A. M. del Mundo. 1963. Eating quality of seven varieties of lowland rice. Philippine Agri. 47 : 207-213.
14. Onate, L. U, A. M. del Mundo and B. O. Juliano. 1964. Relationship between protein content and eating quality of milled rice. Philippine Agri. 47 : 441-444.
15. Perez, C. M. 1979. Gel consistency and viscosity of rice. In proceeding of the wtorkshop on chemical aspects of rice grain quality. IRRI. p291-302.
16. Perez, C. M. and B. O. Juliano. 1977. Gel consistency as an indicator of eating quality of rice. IRRI. Saturday seminar.
17. Perez, C. M. amd B. O. Juliano. 1979. Indicator of eating quality for nonwaxy rice. Fd. Chem. 4 : 185-195.
18. Willams, V. R., W. T. Wu, H. Y. Tsai and H. G. Bates. 1958. Varietal differences in amylose content of rice starch. J. Agri. Food Chem. 8 : 47-48.

稻米食用品質之改良[I]

I. 米粒顆粒澱粉含量及膠體軟硬度之變異[1]

郭益全　謝順景[2]

摘　要

米粒之顆粒澱粉含量及膠體軟硬度爲稻米食用品質的兩個重要指標，本研究之目的在發展一快速可靠的去脂方法以解決顆粒澱粉含量分析去脂耗時之困難，並探討膠體軟硬度之穗內、株內及株間的變異，結果如下：

1. 由去脂與不去脂材料之顆粒澱粉含量值的差異知，爲避免分析中脂肪對光電比色讀數之干擾，糙米粉末之去脂是必須的，而研究中筆者之簡化省時的去脂方法與 Soxhlet 方法有相同的效果。

2. 印度型稻品種之顆粒澱粉含量較日本型品種者高，反之，印度型稻品種之膠體軟硬度則較日本型稻品種者硬。

3. 膠體軟硬度並無株內穗間及穗內（基、中及頂）之差異，表示作膠體軟硬度分析時，以穗之任一部位或株之任一穗行測定均具有株之代表性。

4. 同試區樣品之膠體軟硬度具株間之差異，暗示土壤及其他環境因素爲造成此項差異之原因。

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2. 本所農藝系技士及技正兼系主任。臺灣省 臺中縣 霧峰鄉。